

Effects of Plains Pocket Gopher (Geomys bursarius) Disturbances in a Mixed Prairie in Northwestern Minnesota

Nicole Adams¹, Megan Fillmore², Mark Frost¹, Christopher Sinton¹
University of Minnesota¹, College of St. Catherine²

ABSTRACT

Our objective was to determine what effect plains pocket gophers (*Geomys bursarius*) and their mounds have on plant diversity within Frenchman's Bluff Scientific and Natural Area (SNA), located in northwestern Minnesota. Our predictions were threefold. First, we predicted increased plant diversity in areas on and immediately surrounding gopher mounds in accordance with the Intermediate Disturbance Hypothesis. Second, we predicted that biomass in the areas on and around gopher mounds would decrease when compared to control areas where there were no gopher mounds. Lastly, we predicted that yellow sweet clover (*Melilotus officinalis*) will be more abundant on and around the disturbed mounds than in areas where there is no gopher disturbance. The experiment was performed in one afternoon at Frenchman's Bluff by creating a 100x100 meter grid and assessing plant diversity and coverage in twenty 2x2 meter randomly selected control plots and comparing with twenty 2x2 meter plots that contained gopher mounds created by *G. bursarius*. Analysis of percent coverage of yellow sweet clover, biomass and species diversity between the gopher mound and control plots all proved to be statistically insignificant, but are all nearing significance. Given the number of experimental difficulties experienced and the limited scope of this study, it is likely that future research into the effects of the plains pocket gopher activity on plant diversity at the Frenchman's Bluff SNA will realize conclusive and significant results that correlate with the predictions of this study.

INTRODUCTION

Species diversity, which varies greatly through space and time, has been a major focus of ecological study for some time. Many factors have been hypothesized to influence richness and biodiversity (Mackey and Currie, 2001), including disturbance. Disturbance is widely believed to be one of the most significant factors influencing variations in species diversity (Connell, 1978, Mackey and Currie, 2001). Species richness, the number of biological species in a particular community, is predicted to be highest at intermediate levels of disturbance (Kondoh, 2001). Medium levels of disturbance create a balanced trade-off between competitive exclusion and a species' ability to thrive under stress. This is known as the Intermediate Disturbance Hypothesis, first proposed by Grime in 1973. Since then, it has been widely tested and accepted. Though areas affected by intermediate disturbance will have reduced biomass due to the disturbance, species richness is in no way reduced because competitive exclusion by the previously dominant

species decreases. Therefore, intermediate levels of disturbance maximize species richness within a productive ecosystem.

Prairies are significant ecosystems because they are rich in biodiversity, including animals such as pocket gophers (*Geomys*) and the elusive moonwort (*Botrychium gallicomontanum*). However, since the European settlement of America, the area occupied by native prairie has declined by as much as 99% and species extinction in grasslands is of serious concern as the plains shrink (Samson and Knopf, 1994). Additionally, invasive species are on the rise and are affecting prairie biodiversity. Many Midwestern prairies have been overrun with exotic plants. These invading species influence diversity and modify the ecosystem by shading out native species and altering nutrient levels (Grime 1979). For example, yellow sweet clover (*Melilotus officinalis*) has been shown to drive out native plants and promote not only its own abundance, but the abundance of other exotic species as well (Wolf et al., 2003).

Understanding community interactions within the prairie may help us to understand how prairies work and how grassland species might be conserved. Taking a look at the effect pocket gophers have on prairie plant diversity and invasive species survival could be beneficial to prairie conservation since recent hypotheses on the maintenance of species diversity have emphasized the role of natural disturbance (Martinsen et al., 1990).

Plains pocket gophers (*Geomys bursarius*) are fossorial rodents found in midgrass and tallgrass prairies throughout North America (Hazard, 1982). They are important agents of soil alteration in grasslands and have been labeled 'ecosystem engineers' because their physical activities create microhabitats that alter resource availability for other organisms (Rogers et al., 2001). Their physical activities stem from their specialized front claws which they use to forage for roots and to create extensive burrow systems. Construction of these burrow systems in

grasslands often expels soil aboveground, creating mounds that bury local vegetation and cause localized disturbance (Klaas, et al., 2000). Mounds are thought to influence plant species diversity by acting as seed catchments and providing space and resources for less competitive, colonizer species to become established (Rogers et al., 2001).

Gopher disturbance occurs in small patches and is neither too rare nor too frequent. The Intermediate Disturbance Hypothesis predicts highest diversity within this intermediary level of disturbance (Martinsen et al., 1990). Previous studies of pocket gophers have focused primarily on types of plants that colonize gopher mounds after mound production. Rogers et al. (2001) compared vegetative areas directly next to mounds with the mounds. Many studies have focused exclusively on gopher activity or on soil and nutrient concentrations around mounds. Martinsen et al. (1990) attempted to quantify disturbance caused by gopher activity, but few studies have looked at the Intermediate Disturbance Hypothesis and species diversity in areas where there are gopher mounds compared to areas where there are not.

The purpose of our study is to examine the effect of gopher mound production on plant diversity in a northwestern Minnesota prairie, Frenchman's Bluff SNA. We predicted: (1) increased plant diversity in areas on and immediately surrounding gopher mounds in accordance with the Intermediate Hypothesis Theory, (2) decreased biomass in the areas on and around gopher mounds compared to areas where there are no gopher mounds and (3) that yellow sweet clover will be more abundant on and around the disturbed mounds than in areas where there is no gopher disturbance.

METHODS

Site Description – Research was conducted at Frenchman's Bluff Scientific and Natural Area, a northwestern Minnesota prairie that overlooks the Red River Valley. It is a glacial

moraine that sits atop beach deposits associated with glacial Lake Aggasiz (Farrar and Johnson-Groh, 1991). The bluff is an unusual mix of tallgrass prairie and shorter grasses more typical of western prairies and contains mesic to dry native prairie vegetation (MDNR website). The site has been burned periodically, but had not been burned recently at the time of data collection. Recent gopher activity was apparent due to active mounds and burrows.

Experimental design and sampling methods-- A 100x100 m square plot within the prairie was chosen to conduct the study. Twenty active gopher mounds were identified and flagged for data collection, and 20 randomly generated sets of coordinates were used to determine the control plots, areas where no gopher holes were present, for data collection. The sampling of the 40 plots was allocated between four groups of people with each group collecting data from five gopher plots and five control plots. In each area of proposed data collection within the 100x100 m plot, a 2x2 m plot was determined, and samples were taken from within this area. For each 2x2 m plot being sampled, the total number of species, an estimation of the percent cover of each of these species, and an estimation of percent cover of the invasive species yellow sweet clover was determined. Also, within each 2x2m plot, a .1x.1m section was randomly determined, and the biomass within this area was collected and bagged. This procedure was done for the 20 gopher holes chosen within the 100x100 m plot, as well as for the 20 randomly selected control areas.

Data analysis and statistical procedure -- T-tests and a one way ANOVA were performed on the data to determine significant differences between the two study areas.

RESULTS

Our experiment tested several variables between the gopher mound and control locations. There was no truly significant difference found between the two sites for the number of species,

total percent coverage, percent coverage of yellow sweet clover, or average biomass. The majority of tests however did show strong trends supporting our predictions. A higher average number of species was seen in the gopher mound plots, than control plots (Fig. 1). A one-tailed t-test of the average number of species shows a moderate statistical significance ($t = 1.50$, $df = 18$, $p = 0.076$). The control plots show a slightly higher average percent coverage but a one-tailed t-test shows a lack of statistical significance ($t = 1.14$, $df = 18$, $p = 0.134$). To compare species density the Shannon-Weaver Density Index was calculated for each plot in order for the gopher mound plots to be compared to the control plots (Fig. 2). A one-tailed t-test comparing the Shannon Weaver density means gave a statistically insignificant correlation ($t = 1.25$, $df = 18$, $p = 0.115$). The percent coverage of yellow sweet clover was observed to be considerably higher in the gopher mound plots (Fig. 3). A one-tailed t-test confirmed moderate significance ($t = 1.40$, $df = 18$, $p = 0.089$). Both the gopher mound and control plots contain similar biomass as shown by the one-tailed t-test ($t = 1.24$, $df = 13$, $p = 0.118$) (Fig. 4). After analyzing individual group data a significant trend appeared showing two groups consistently identifying more species than the other two groups (Fig. 5). A one way ANOVA confirms a statistically significant difference in number of plant species identification to be present between groups ($FC = 2.87$, $df = 3$, $p < 0.001$).

DISCUSSION

Overall, the results of this experiment are mixed. While none of the areas of study showed a statistically significant difference between the mounds of the gopher *G. bursarius* and random control plots at Frenchman's Bluff Scientific and Natural Area, there is still a notable trend towards difference between the two types of plots. Given these trends, the late spring at Frenchman's Bluff and the experimental difficulties that were experienced, further study of the

effects of *G. bursarius* mounds at the Frenchman's Bluff SNA are justifiable and likely to yield more conclusive results.

Biodiversity

When assessing the difference in number of different plant species between plots containing gopher mounds and control plots devoid of gopher activity, there is no statistically significant difference apparent. The p-value of 0.076, while not significant, still implies that there is a definite trend towards a greater variety of plant species present on gopher mounds. (Fig.1) It is likely, however, that there actually is a significant difference between the two plot types. There are several reasons to support this line of thinking, the first and most significant of which was the lack of experience in identifying plant species by many of those involved in the sampling of the plants. This difference is illustrated by the results of the one way ANOVA test which confirms that there is a statistically significant (<0.001) difference between the number of plant species identified between some of the groups. Those groups that had surveyors with the most experience in identifying prairie plant species identified significantly more species than did those that were populated with surveyors with little or no experience in identifying different plant species. It is quite plausible that there is enough error based on this alone to have shifted the results out of the range of statistical significance. Given the marginal significance of this result, and the fact that many of those conducting the sampling were inexperienced, it is quite likely that future studies with more experienced surveying groups will see more conclusive and statistically significant results. The Shannon-Weaver test was also used to analyze diversity between the control plots and the gopher mound plots. Once again, the results of this statistical test were not significant. There is, however, reason to believe, based on human error during sampling and the late spring that the study area experienced, that a subsequent study would

obtain more conclusive results. While analysis of biodiversity provides results that are only of marginal statistical significance, they still support the hypothesis that plant diversity will be greatest in plots containing a gopher mound and that yellow sweet clover will be promoted on areas disturbed by gopher activity.

Percent Coverage by Yellow Sweet Clover

Comparing the percent coverage of yellow sweet clover (*Melilotus officinalis*) helps to illustrate any difference in the relative abundance of the species between gopher mound plots and control plots. This comparison is of particular use to this experiment. Given the results, it would appear that yellow sweet clover is promoted on gopher mounds and is less abundant in the control plots. While the result is not statistically significant, the trend is quite apparent and correlates with previous studies of a similar nature (Wolf, et. al). It also makes logical sense. As an invasive species, yellow sweet clover is less competitive and is able to take hold primarily by its ability to distribute rapidly and crowd out other species. As the gopher mounds provide a disturbance that opens a small area to any new plant, it is likely that yellow sweet clover would be able to exploit this to its advantage, and establish itself where it would otherwise not be able to compete. The lack of statistical significance in these findings is primarily due to the small amount of yellow sweet clover that was observed in the field. This is likely the result of the late spring experienced in the study area this year. If the study is repeated later in the year, when yellow sweet clover has had more time to grow, it is likely that more individuals will be tallied and the results of the statistical tests will reach significance. The inconclusiveness of this aspect of the experiment is primarily due to limitations on scope, and not from experimental procedure. Overall, these results bode well for future investigations of a similar or larger scale.

Biomass analysis

Comparison of the biomass of plant species between plots with gopher mounds and control plots shows that there is a noticeable trend towards increased biomass in the control plots. While the result is not of statistical significance, the trend is nonetheless evident. It is within the realm of possibility that a more extensive study in the future will realize a more significant result. The results of this study, however, support the prediction that plant biomass will be greater at the control plots than at the gopher mounds and correlate with other studies of a similar nature (Rogers, et al).

Future Implications

While none of the results of this study are of true statistical significance, they are quite promising in regards to the potential findings of future studies on the effects of *G. bursarius* on plant diversity at Frenchman's Bluff SNA. There are definite trends present in the data that support the predictions of this study even if the results are not quite statistically significant. Given the limitations of the study, and how near to statistical significance many of the results are, it is quite likely that a subsequent study without the limitations experienced while conducting this experiment would achieve significant results that match the predictions of this study.

FIGURES

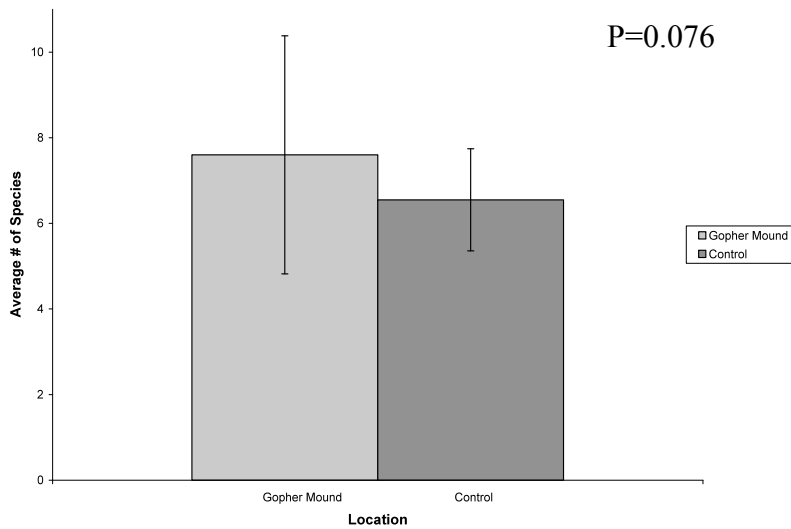


Figure 1: The Average Number of Species per Location. Two different location types in Frenchman’s Bluff Prairie were sampled, with 20 samples taken from areas near gopher mounds, and 20 samples taken from areas without (control) within a 100x100m plot. The number of different species from each location type was identified within a 2x2m plot size around the specified location, and recorded. Each bar represents the average number of different species, according to the different location. Error bars represent a + or – 1 standard deviation. A t-test was done calculating a p-value of 0.076(one tailed test).

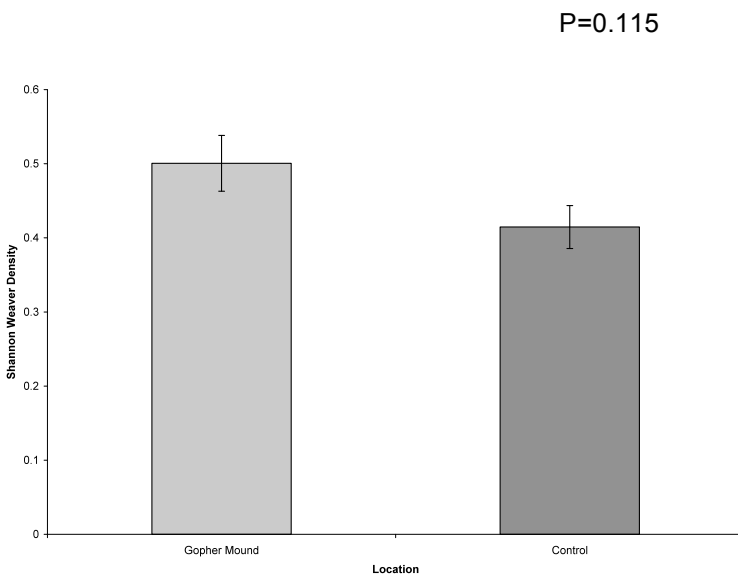


Figure 2: The Shannon Weaver Density Index per Location. Two different location types in Frenchman’s Bluff Prairie were sampled, with 20 samples taken from areas near gopher mounds, and 20 samples taken from areas without (control) within a 100x100 m plot. The number of different species from each location type was identified within a 2x2m plot size around the specified location. The percent coverage of each different species was estimated, and the Shannon Weaver Density Index was calculated with these values, according to plot type. Each bar represents the Shannon Weaver Index for the specified location. Error bars represent + or – 1 standard deviation. A t-test was performed and calculated a p-value of 0.115 (one tailed test).

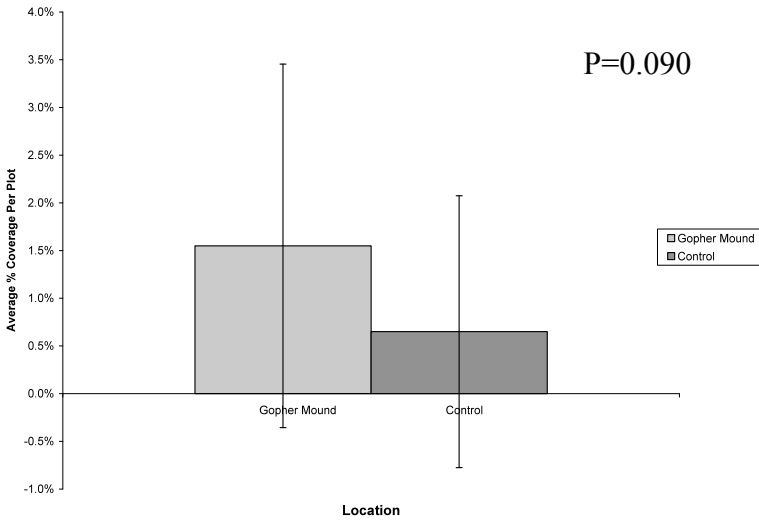


Figure 3: Average Percent Coverage of Sweet Clover per Location. Two different location types in Frenchman’s Bluff Prairie were sampled, with 20 samples taken from areas near gopher mounds, and 20 samples taken from areas without (control) within a 100m by 100m plot. The number of different species from each location type was identified within a 2x2 m plot size around the specified location. The percent coverage of the plant species yellow sweet clover was estimated for the 40 plots. The average percent cover of yellow sweet clover was calculated for the 20 gopher mounds, as well as for the 20 control areas. Each bar represents the average percent coverage of yellow sweet clover per location. Error bars represent + or – 1 standard deviation. A t-test was performed and a p-value of 0.090 was calculated.

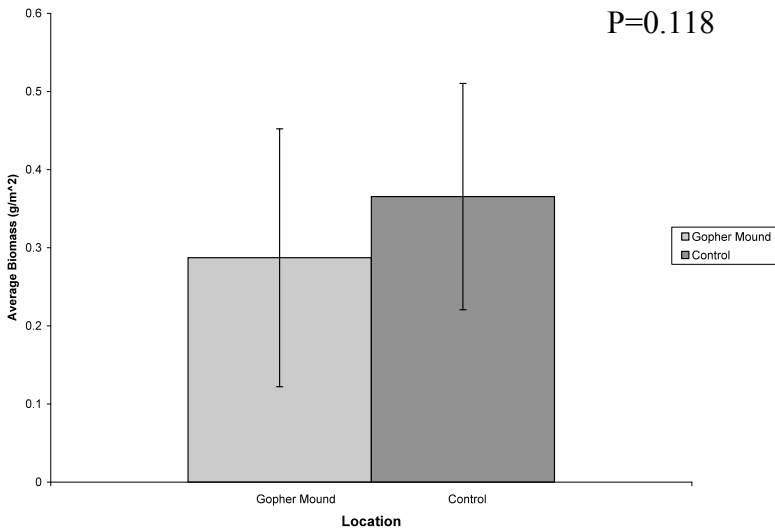


Figure 4: Average Biomass of plant species within a .1x.1m plot per location. Two different location types in Frenchman’s Bluff Prairie were sampled, with 20 samples taken from areas near gopher mounds, and 20 samples taken from areas without (control) within a 100mx100m plot. Within 30 of the sample areas, a .1x.1m plot was randomly selected, and all of the aboveground plant material collected. This material was weighed and averaged based on location area. Each bar represents the average biomass collected for the specified location. Error bars represent + or – 1 standard deviation. A t- test was performed and a p-value of 0.118 was calculated (one tailed test).

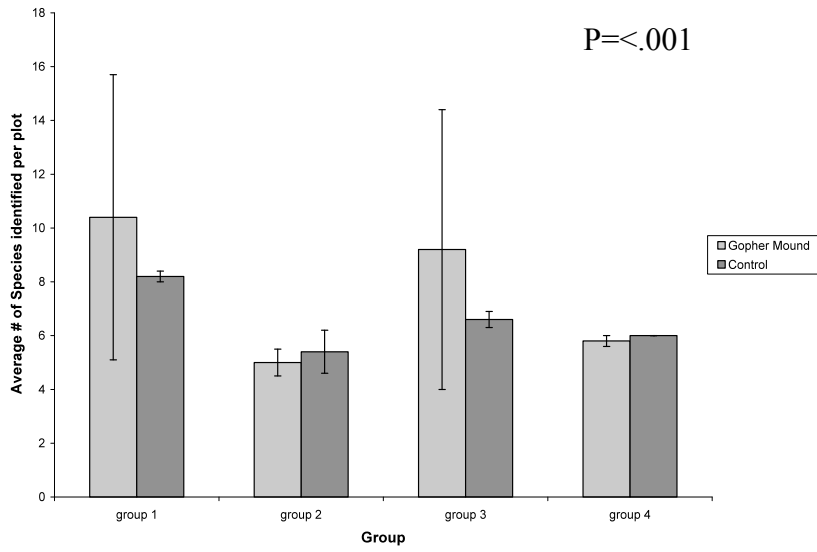


Figure 5: The Average number of species identified per group per site. Two different location types in Frenchman’s Bluff Prairie were sampled, with 20 samples taken from areas near gopher mounds, and 20 samples taken from areas without (control) within a 100x100 m plot. 4 different groups sampled specified locations within a 100x100 m sample space and the averages number of species determined per location by each group was calculated. Each bar represents the average number of species identified per location by the specified group. Error bars represent + or – 1 standard deviation. A one way ANOVA was used to calculate a p-value of <math>< .001</math>.

SOURCES CITED

- Connell, J. H. (1978). Diversity in tropical rain forests and coral reefs. *Science*, 199, 1302–1310.
- Farrar, D.R., Johnson-Groh, C.L.(1991). A new prairie moonwort (botrychium subgenus botrychium) from northwestern minnesota. *American Fern Journal*, 81, 1-6.
- Grime, J. P. (1973). Competitive exclusion in herbaceous vegetation. *Nature*, 242, 344-347.
- Grime, P. (1979). *Plant strategies and vegetation processes*. New York: John Wiley and sons.
- Hazard, E. B. (2001). *The Mammals of Minnesota* (Sixth ed.). Minneapolis: The University of Minnesota Press. (Original work published 1982)
- <http://www.dnr.state.mn/us/snas/sna00971/index.html#>
- Klaas, B. A., Moloney, K. A., Danielson, B. J.(2000). The tempo and mode of gopher mound production in a tallgrass prairie remnant [Electronic version]. *Ecography* , 23(2), 246-256.
- Kondoh, M. (2001). Unifying the relationships of species richness to productivity and disturbance [Electronic version]. *Proceedings: Biological Sciences*, 268(1464), 269-271.
- Mackey, R. L., Currie, D. J. (2001). The diversity-disturbance relationship: is it generally strong and peaked? [Electronic version]. *Ecology* , 82(12), 3479-3492 .
- Martinsen, G. D., Cushman J. H., Whitham T. G. (1990). Impact of pocket gopher disturbance on plant species diversity in a shortgrass prairie community. [Electronic version]. *Oecologia*, 83(1), 132-138.
- Rogers, W. E., Hartnett, D. C., Elder, B. (2001). Effects of plains pocket gopher (*Geomys Bursarius*) disturbances on tallgrass-prairie plant community structure [Electronic version]. *American Midland Naturalist*, 145(2), 344-357.
- Samson, F., Knopf, F.(1994). Prairie conservation in north america. *Bioscience*, 44(6), 418-421.
- Samson, F.B., Knopf, F.L., MCarthy, C.W., Noon, B.R., Ostlie, W.R., Rinehart, S.M, Larson, S., Plumb, G.E., Schenbeck, G.L., Svingen, D.N., Byer, T.W. (2003). Planning for population viability on northern great plains national grasslands. *Wildlife Society Bulletin*, 31, 986-999.
- Wolf, J.L., Beatty, S.W., Carey, G. (2003). Invasion by sweet clover (*Melilotus*) in montane grasslands, rocky mountain national park. *Annals of the Association of American Geographers*, 93, 531-543.